COUNTERMEASURES FOR MITIGATION OF SENSORIMOTOR DECREMENTS FOLLOWING HEAD-DOWN BED REST

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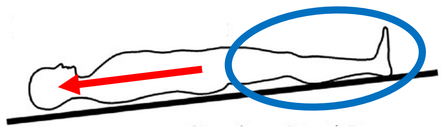
BACKGROUND

- Proprioceptive deconditioning induced by body unloading during spaceflight plays a significant role in postflight balance impairments.
- Current in-flight exercise countermeasures do not fully protect postflight balance control, and exploration spaceflight will lack key exercise capabilities (e.g., treadmill).
- Two potential inflight countermeasures have been identified for evaluation in a body unloading spaceflight analog, head down bed rest (HDBR):
  - Proprioceptive training
  - Electrical muscle stimulation (EMS)

OBJECTIVES

- This study will determine the effects of proprioceptive training and EMS on functional task performance and sensorimotor function following 60 days of 6° HDBR.
- Associations between changes in functional task performance and changes in key physiological factors will be explored.

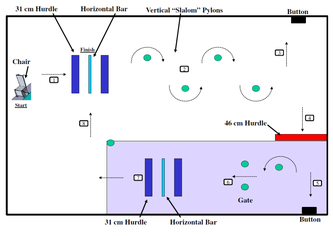


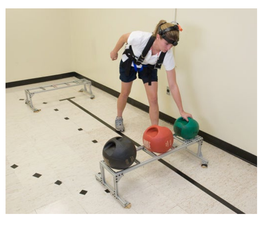
METHODS

- Subjects will be randomly assigned to one of four groups:

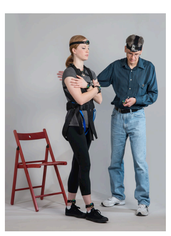
EMS	Daily bilateral stimulation of the quadriceps femoris muscle (30 minutes per session)
Proprioceptive Training (PT)	Horizontal postural challenges three days per week (20 min per session)
Exercise plus PT (EPT)	Exercise training will mimic current protocols used on the ISS, with resistance training and cycle aerobic training (but no treadmill)
Control (CON)	Periodic horizontal position to match the other groups

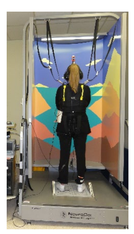
- Primary outcome measures: functional tasks that are representative of high priority exploration mission tasks and require high demand for dynamic control of postural stability.
  - ➢ Seat Egress and Walk Test (also referred to as the Functional Mobility Test)
  - ➢ Recovery from Fall, Object Translation, Jump Down

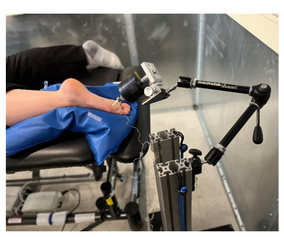


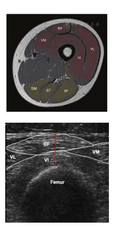


- Key physiological factors:
  - ➢ Sensorimotor Function, Somatosensory Feedback, Musculoskeletal Structure and Function





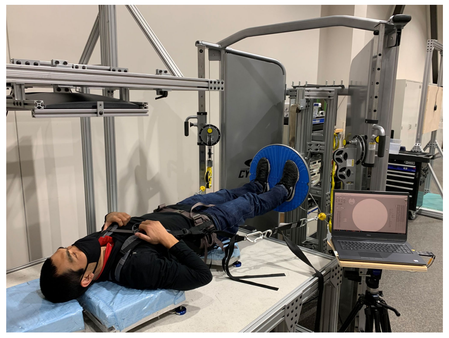




  - ➢ Cardiovascular Health, Ocular Function, Blood Biomarkers
- Given the constrained samples size, a Bayesian modelling approach will be used to quantify the probability that there is an effect of a given magnitude.

COUNTERMEASURES

- Proprioceptive training:
  - ➢ Rationale:
    - 1) Proprioceptive deconditioning induced by body unloading plays a significant role in postflight balance impairments[1,2].
    - 2) Postflight, there is an up-weighting of more reliable non-vestibular information[3,4].
    - 3) Foot pressure stimulation and massage during spaceflight/analogs have shown beneficial effects on postflight/post-analog postural control[5-7].



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  - ➢ Goal: to keep the proprioceptive and tactile systems conditioned and adaptable to challenges such as upright balance in a gravitational environment.
  - ➢ Proprioceptive training program for 60 days of HDBR.
    - Maintain an appropriate challenge:
      - Progressively decrease the subject's base of support.
      - Increase tilt board target distances.
      - Increase axial loads.
      - Use both subjective verbal feedback and objective performance data.

	Double-Leg Progressions			Single-Leg Progressions	
Level	Feet	Load	Targets	Load	Targets
1	Shoulder	50-60%	15°	30-40%	5°
2	Shoulder	70-80%	15°	50-60%	5°
3	Together	50-60%	10°	50-60%	10°
4	Together	70-80%	15°	70-80%	5°
5	Semi-Tandem	70-80%	10°	70-80%	10°
6	Semi-Tandem	90-100%	15°	90-100%	5°
7	Tandem	70-80%	10°	90-100%	10°
8	Tandem	70-80%	15°	90-100%	15°
9	Tandem	90-100%	15°		

- EMS:
  - ➢ Rationale: EMS has been shown to be effective in promoting muscle growth and maintaining muscle mass in situations where there is reduced limb use. However, there have been relatively few studies in humans either during spaceflight or terrestrial analogous, including extended HDBR, and thus there remains uncertainty as to its actual efficacy.
  - ➢ Methods: We will use a commercial muscle stimulating device (such as the Compex device shown below) on 4 muscles bilaterally in both lower extremities, performing stimulation for approximately 30 minutes twice daily in one set of subject and simple placement without stimulation in a control group. Specific outcome measures will include measures of strength, muscle volume, and muscle impedance parameters, in addition to the proprioceptive outcomes which may also have the potential to be impacted.

RELEVANCE

- Deliver proof-of-concept sensorimotor countermeasure designs with full assessment of efficacy in a spaceflight analog.
- If the countermeasures are effective, they will be translated for validation on the ISS.

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